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**What proportion of people who try one cigarette become daily smokers? A
meta analysis of representative surveys.**

Max Birge* (MChem, MBBS), Stephen Duffy* (PhD), Joanna Astrid Miler*** (PhD), Peter
Hajek (PhD)*

* Barts and the London School of Medicine & Dentistry, Queen Mary University of London,
Turner Street, London E1 2AD

** Institute of Health and Wellbeing, University of Glasgow, 1055 Great Western Road,
Glasgow, G12 0XH

Correspondence to: Joanna Astrid Miler, Institute of Health and Wellbeing, College of
Medical, Veterinary and Life Sciences, Mental Health and Wellbeing, University of Glasgow,
Admin Building, Gartnavel Royal Hospital, 1055 Great Western Road, Glasgow, G12 0XH
Email address: joannaastridmiller@gmail.com

ABSTRACT

Introduction: The 'conversion rate' from initial experimentation to daily smoking is a potentially important metric of smoking behavior, but estimates of it based on current representative data are lacking.

Methods: The Global Health Data Exchange was searched for representative surveys conducted in English speaking, developed countries after year 2000 that included questions about ever trying a cigarette and ever smoking daily. The initial search identified 2776 surveys that were further screened for language, location, year, sample size, survey structure and representativeness. 44 surveys that passed the screening process were accessed and their codebooks were examined to see whether the two questions of interest were included. Eight datasets allowed extraction or estimation of relevant information. Survey quality was assessed with regards to response rates, sampling methods and data collection procedures. PRISMA guidelines were followed, with explicit rules for approaching derived variables and skip patterns. Proportions were pooled using random effects meta-analysis.

Results: The eight surveys used representative samples of the general adult population. Response rates varied from 45% to 88%. Survey methods were on par with the best practice in this field. Altogether 216,314 respondents were included of whom 60.3% (95%CI 51.3-69.3) ever tried a cigarette. Among those, 68.9% (95% CI 60.9-76.9%) progressed to daily smoking.

Conclusions: Over two thirds of people who try one cigarette become, at least temporarily, daily smokers. The finding provides strong support for the current efforts to reduce cigarette experimentation among adolescents.

IMPLICATIONS:

The transition from trying the first cigarette through occasional to daily smoking usually implies that a recreational activity is turning into a compulsive need that has to be satisfied virtually continuously. The 'conversion rate' from initial experimentation to daily smoking is thus a potentially important metric of smoking behavior, but estimates of it based on representative data are lacking. The present meta analysis addressed this gap. Currently, about two thirds of non-smokers experimenting with cigarettes progress to daily smoking. The finding supports strongly the current efforts to reduce cigarette experimentation among adolescents.

INTRODUCTION

Habitual smoking, once established, can be highly resistant to change [1]. A substantial proportion of smokers continue to smoke despite professing a desire to quit [2-3], and those attempting to quit face more than a 90% probability that they will return to smoking within a year [4]. In some smokers, the activity acquires all the characteristics of extreme dependence [5].

In the development of any addictive behaviour, the transfer from experimentation to daily practice represents an important landmark [6]. The transition from trying the first cigarette through occasional to daily smoking usually implies that a recreational activity is turning into a compulsive need that has to be satisfied virtually continuously [7-8]. Adolescent smokers can show signs of dependence early on, before progressing to daily smoking [9] but such individuals typically do progress to daily smoking eventually, while people who remain occasional smokers tend to display few signs of dependence [10-11].

The rate of the transfer from the first experimentation with cigarettes to daily smoking (referred to as the 'conversion rate' throughout this paper) would seem to be an essential piece of information needed to guide policies concerned with tobacco experimentation in adolescents. If most adolescents who experiment with smoking abandon the behaviour at its early stages, preventing such opportunities would be less important than if the transfer from experimentation to daily smoking was common.

So, what proportion of people who tried a single cigarette progress to daily smoking? Surprisingly, few attempts exist to answer this question. MAH Russell, the pioneer of

tobacco dependence research, used figures from a 1967 cross-sectional survey of 984 UK adults [12] to calculate that of people who smoked one cigarette, 70% went on to smoke regularly for five years or more [13]. The estimate was based on a relatively small sample dating from the time when smoking was highly prevalent and socially acceptable. We are aware of one other study of a general population sample that reported 68% of ever smokers progressing to daily smoking [14]. There are of course newer studies that have attempted to assess the dependence potential of smoking but this was done by e.g. estimating the proportion of adolescent and/or adult smokers who can be classified as dependent using indices such as DSM criteria, smoking the first cigarette of the day within 30 minutes of waking up, reporting urges to smoke or irritability when unable to smoke or experiencing difficulty refraining from smoking [e.g. 9,15-20]. The conclusions varied depending on which criteria of dependence were adopted.

Further current empirical data from which an estimate of the rate at which experimentation with cigarettes translates into daily smoking could be derived exist. Several surveys of the general population have been conducted that ask the respondents whether they had ever tried smoking and whether they have ever smoked daily. We undertook a systematic review of all the existing data sets to provide as comprehensive an answer to the question in the title of this report as possible.

METHODS

Study design

This was a systematic review of available representative surveys of the general population that ask whether respondents had ever tried a cigarette and whether they have ever been a daily smoker. The review followed the PRISMA protocol [21], see Figure 1.

Search Strategy

We used the Global Health Data Exchange [22], which is the most comprehensive existing catalog of survey datasets and other health-related data, with the search term: 'tobacco' and filter type: 'survey'. The search was performed in March-April 2016, giving 2776 results. Filtering the results to English speaking developed countries yielded 509 surveys: 151 from the UK (England, Scotland, Wales and Northern Ireland), 277 from North America (USA and Canada), and 81 from Australasia (New Zealand, and Australia). Finally, a time filter was applied to only include surveys published between the years 2000-2016 to make access to primary data easier and to homogenize the sample. (The Global Health Data Exchange catalogs data from the year 1900 onwards). The remaining 260 surveys were screened by two reviewers (JM and MB). Titles limiting the sample to subsets of the general population were excluded ("child" or "children" or "youth" or "adolescent" or "school" or "senior"). Where a survey was regularly repeated – as part of a series examining trends over time – only the most recent available version was used. Codebooks from each of the remaining 44 surveys were examined to see whether the two questions of interest were asked directly or could be inferred, i.e. whether respondents ever tried a cigarette and whether they ever smoked daily, and whether the survey used a representative population sample. Appendix 1 provides verbatim wording of the relevant questions used in each included survey.

Where access was restricted in surveys that met the above criteria (three surveys), we followed the application procedures for access. We were granted the access in two cases [23, 24] but not in one other [25]. Figure 1 shows the PRISMA flow diagram.

FIGURE 1 about here

We were also made aware of one other relevant survey (National Comorbidity Survey - Replication, analysed by Dierker et al. 2008 [14]. The analysis provides the actual conversion rate and we added this to our meta-analysis and analysed the data including and excluding this survey.

Altogether eight surveys provided relevant data.

Quality of included surveys

We assessed sample sizes, representativeness, data collection methods and response rates of each included survey. Sample sizes ranged from 6,237 to 60,192. All surveys were designed to generate a random, representative sample of the general adult population. All surveys utilized current census data in a multi-stage stratification process. Generally, this involved first dividing a population into geographical units before further stratification based on relevant socioeconomic and personal indicators (e.g. income, age, ethnicity and gender). All surveys were conducted on behalf of governments. Data collection methods included computer assisted, fieldworker conducted interviews [26-28, 30] supplemented by paper self-completion questionnaires [27-28] and interviews over telephone [30]; telephone interviews only [29] , and a self-completed paper questionnaire that was either distributed and collected by the fieldworker or mailed in by the participant [23]. In five surveys respondents were paid either before the interview took place [30, 27-28] or upon completion [26, 29]. Response rates varied between 45% in the only example of a telephone based interview [28] to 88%, in the only example of a longitudinal series [30]. Table 1 lists methods, instruments, response rates and incentives in included surveys.

TABLE 1 about here

Despite relatively low response rates in some surveys, we consider the survey methods to be on par with the best practice in this field.

Data extraction

The degree of processing required to determine the number of daily and experimental smokers varied across surveys due to differences in questionnaire design, non-derived/derived variables (where there was a direct question or the variable of interest had to be derived from grouping or combining answers to other questions) and 'skip-patterns' (where participants were directed to skip sections of the survey contingent on their answers to previous questions).

Generally, answers to the two questions of interest (number of participants who ever tried a cigarette, and number who ever smoked daily) were not available in published survey results and had to be extracted from microdata.

Two surveys [23, 26] used a single question to ascertain experimental smoking and a single question for ever-daily smoking. Three UK surveys [30, 27, 28] used similar questions concerning experimental smoking, but the daily smoking question was divided into past-daily and current-daily smoking and further divided into weekend and weekday use. Two surveys [27, 28] reported derived variables that re-categorised the answers into four smoking status options: current/former-daily/former-occasional/never smoker. As formal definitions of these categories were not provided, we analysed the survey skip-patterns and combinations of the answers to multiple questions to verify and adjust survey-derived variables. In one survey [30] we used three survey questions via skip pattern analysis to derive answers to both experimental and ever-daily smoking questions. In another survey [29], a respondent-age dependent skip pattern required a formula that combined answers to four questions. In this case (and generally, where possible), an alternative question was also used to check for consistency.

Details of data extraction used in different surveys are listed in Appendix 1.

All surveys use “weighting” methodologies to minimize bias inherent in the population sampling methods. Statistical methods vary and can include adjustments made pre- or post-data processing (e.g. removing data from over-sampled sub-populations or using weighting factors on raw results) or both. For consistency, we did not use post-processing weightings, as this could not be applied to data sets where we had to derive the relevant figures ourselves [27-30] or where necessary details were not available [24]. In a sample comparison of the results using weightings and using raw numbers, the difference was <1%.

Data analysis

We obtained overall estimates by random effects meta analysis [31]. This was because we anticipated that the underlying population proportions in each survey were unlikely to be identical.

RESULTS

Table 2 presents the results from each survey and from the overall survey sample.

TABLE 2 about here

Across surveys, 60.3% (95%CI 51.3-69.3) of respondents have ever tried smoking and 41.2% (95% CI 33.5-48.9%) were ever-daily smokers.

The conversion rate from trying a cigarette to becoming a daily smokers ranged from 50% in one of the US surveys to 82% in one of the UK surveys. A simple pooling of all studies gives an overall estimate of 65.1% (95% CI 64.8-65.4%). The random effects weighted mean percentage across the surveys was 68.9% (95% CI 60.9-76.9%). Excluding the survey for which we had to impute the total number and the number of daily smokers, the weighted mean random effects estimate was 69.1% (95% CI 60.3-78.0%).

We tested the hypothesis that the differences in 'conversion rate' between surveys are related to surveys' response rates. Smokers can be expected to be less likely to respond to smoking surveys than non-smokers for at least two reasons: Smoking rates are high in populations such as the homeless and people with mental health problems [32-33] who are less likely to respond to surveys; and in developed countries where smoking is generally viewed as an undesirable behavior [34], smokers can be expected to be less keen to respond to such surveys than non-smokers [35-37]. As the "conversion rate" includes current smokers among ever smokers, lower response rates could be accompanied by lower smoking rates and also lower 'conversion' rates. There was no strong correlation between response rates and conversion rates ($r=0.09$).

Discussion

An estimated 69% of people who try a cigarette progress to daily smoking.

The present study has several limitations. Different surveys yielded somewhat different results. Although none found conversion rates below 50%, and an additional survey from a non-English speaking country with a high smoking prevalence fitted well with the other surveys, the variation we observed suggests that the actual figure we arrived at is only approximate. We ruled out the influence of different response rates. The differences

between surveys could reflect random variation, or other factors such as circumstances and formats of the surveys that may have been more or less conducive to recall or convey different social acceptability of smoking and smoking experimentation. There are also questions that can be raised over the accuracy of the recall people have concerning their smoking history. If for instance a proportion of non-smoking respondents forgot that they had tried smoking, the real conversion rate would be lower. Whether a person did or did not try smoking seems to be an easily answerable question and one which does not seem to be subject to any obvious social desirability bias, but such influences cannot be ruled out altogether. Current smoking was likely to be under-reported [e.g. 35-37], but "ever-daily-smoking" seems again an information with neutral value, involving no obvious reason for a systematic response bias. In tobacco use surveys, answers to clear and salient questions seem to be reasonably reliable [38-39], but as in all retrospective surveys, a degree of uncertainty and error is inevitable [e.g. 40].

The differences between surveys in conversion rates suggest that the random effects analysis was appropriate. A simple pooling of all studies provides a lower estimate of 65.0% (95% CI 64.7-65.3%), but with an unrealistic precision of estimation. The random effects analysis gives a somewhat higher average estimate as it uses a smaller differential in weights between large and small studies, and a substantially greater confidence interval, reflecting greater uncertainty. It should be noted that the denominator of the conversion rate, the number ever smoking a cigarette, was itself subject to variation. However, with the numbers of participants in the thousands or tens of thousands, this would not lead to noticeable extra-binomial variation.

The surveys we included were all cross-sectional. Longitudinal studies of representative population samples that would monitor smoking behavior from early adolescence to at least middle age would provide more definitive data. There exist longitudinal surveys that may allow extraction of relevant data (e.g. [41-42]), although they concern opportunistic rather than representative samples and cover only relatively limited time-periods.

We were unable to extract data from one additional survey [14], but we imputed the necessary numbers for the analysis from published percentages. The results including and excluding this survey were almost identical (68.9% and 69.1% conversion rates respectively). Given the high 'conversion rate' from experimentation to daily smoking found in all existing surveys, it can be hypothesized that at least some of the reduction in smoking prevalence observed over the past 20 years is likely due to reduced experimentation with cigarettes among adolescents.

While most experimenters progress to daily smoking, some do not. An important study of adolescent progression to tobacco dependence found that early experimenters are more likely to progress to heavier smoking and dependence [43]. Further work should explore the existing databases to see if any other variables recorded in the relevant surveys are associated with the progression to daily smoking.

Despite some remaining questions, the present study provides a clear and striking piece of information. To the best of the current knowledge, at the current time, about two thirds of non-smokers experimenting with cigarettes become daily smokers.

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Declaration of Interests:

PH provided consultancy to and received research funding from manufacturers of stop-smoking medications. None of the other authors declare any conflict of interest.

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Figure 1: PRISMA Flow Diagram

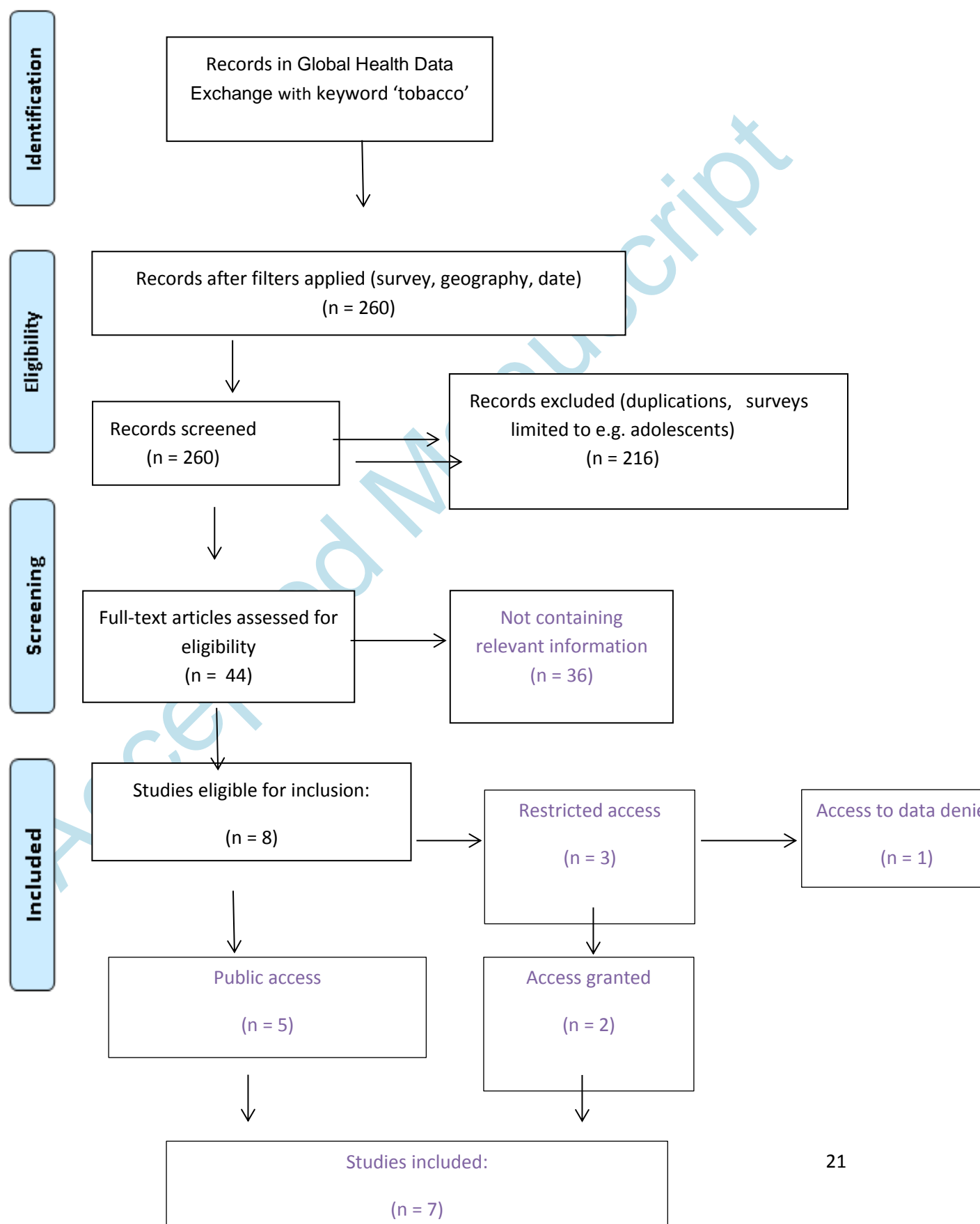


Table 1: Characteristics of included surveys

| Survey | Sampling procedure (key sampling variables) <sampling data source> [age range] | Data collection + survey instruments | Incentive | Response rate |
|---|---|--|---|---------------|
| USA: National Adult Tobacco Survey (NATS) 2012-2013 | Dual frame, stratified random sample (state, age, gender, race, marriage, education, phone) - <census data> [18+] | Landline and cellular telephone interview | \$75 on completion | 45% |
| USA: National Survey on Drug Use and Health (NSDUH) 2013 | Four-stage stratified random sample (state, region, dwelling units, age) <census data> [12+] | In-person computer assisted interview - fieldworker guided | \$30 on completion | 72% |
| USA: National Comorbidity Survey – Replication (NCS-R) 2001-2003 | Four-stage national area sample (state, counties, housing units, language) <census data> [18+] | In-person computer assisted interview – fieldworker guided | \$50 - \$150 on completion (increasing incentive for nonrespondents) | 70.9% |

| | | | | |
|--|--|--|--------------------------------------|---------|
| UK: Understanding Society - Wave 2 (US:W2) 2010 | Multi-stage stratified, clustered random sample (region, postcode, socioeconomic status, density). Three components: new sample of general adult population, ethnic minority boost and previous survey series continuous sample <census data> [16+] Longitudinal series but smoking questions were asked only once. | In-person computer assisted personal interview - fieldworker guided OR telephone interview (if preferred) | £5-10 pre-completion (age dependent) | 75- 88% |
| UK: Health Survey England (HSE) 2014 | Multi-stage stratified random sample (postcode, dwelling units, households) <census data> [16+] | In-person computer assisted interview - fieldworker guided (if >18 years old) OR self-completed questionnaire - fieldworker guided (<18) | £10 pre completion | 62% |
| UK: Health Survey Scotland (HSS) 2014 | Multi-stage stratified random sample (postcode, dwelling units, households) <census data> [16+] | In-person computer assisted personal interview - fieldworker guided (>18) OR self-completed questionnaire - fieldworker guided (<18) | £10 pre completion | 56% |

| | | | | |
|---|---|--|------|-----|
| Australia: National Drug Strategy Household Survey (NDSHS) 2013 | Multi-stage stratified random sample (state, territory, address) - <census data> [12+] | Self-completed paper questionnaire, drop and collect by fieldworker OR mail-in | None | 49% |
| New Zealand: Tobacco Use Survey (TUS, 2009) | Multi-stage, stratified, probability-proportional-to-size (PPS) sample (region, state, households) < census data> [15-64] | In-person computer assisted interview - fieldworker guided | None | 74% |

Table 2 : Proportion of experimental smokers who became daily smokers

| <i>Survey</i> | <i>Country</i> | <i>Total sample (N)</i> | <i>Ever tried smoking (N)</i> | <i>Ever-daily smoker (N)</i> | <i>(%) of ever tried who ever-smoked daily</i> | <i>95% CI</i> |
|---------------|----------------|-------------------------|--|------------------------------|--|------------------|
| NATS | USA | 60192 | 45847 | 29321 | 64.0% | 63.5-64.4 |
| NSDUH | USA | 54335 | 26761 | 13417 | 50.1% | 49.5-50.7 |
| NCS | USA | 7797* | 5692 | 3842* | 67.5% | 64.5-70.5 |
| US: W2 | UK | 50715 | 28052 | 21998 | 78.4% | 77.9-78.9 |
| HSE | UK | 7871 | 4280 | 3477 | 81.2% | 80.0-82.4 |
| HSS | UK | 6327 | 2650 | 2166 | 81.7% | 80.2-83.2 |
| NDSHS | Australia | 23855 | 15632 | 9608 | 61.5% | 60.7-62.2 |
| TUS | NZ | 5222 | 3496 | 2345 | 67.1% | 65.5-68.6 |
| | | 216314 | Random effects mean 68.9% | | | 60.9-76.9 |
| | | 208517 | Random effects excluding NCS mean 69.1% | | | 60.3-78.0 |

*Numbers imputed from percentages quoted in the publication- these will differ from original numbers in the survey as the percentages published are weighted to reflect the total population structure.